

# VANDERBILT UNIVERSITY



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January 27, 1986

*Cumberland Museum  
615-259-6099*

Mr. Robert A. McGaw  
3803 Brighton Road  
Nashville, TN 37205

Dear Bob:

We have completed the testing program for the water issuing from the springs at Grassmere Farm. As detailed in the enclosed short paper by Professor David Wilson, we found only two pollutants of note - iron and diesel oil.

No measurable amounts of volatile hydrocarbons and no measurable amounts of chlorinated hydrocarbons were found at any time in either spring. If there were indeed traces of these compounds in the underground aquifer at one time, they have subsequently either been flushed out or volatilized.

We found trace amounts of various heavy metals in both springs, but nothing unusual and nothing dangerous. The concentrations of all metals except iron in the large spring are well below the applicable federal Drinking Water Standards.

The average total iron concentration in the large spring is approximately 3.0 - 3.5 mg/L, or parts per million. About two thirds of this is already oxidized to ferric hydroxide, or iron rust, when the water issues from the spring. This iron rust is the material which gives the orange color to the stream. Heavy oils are visible on the surface of the stream, are measurable in the water at moderate concentrations, and there is a strong smell of diesel fuel at the spring.

In order to combat both of these problems, we recommend that a combination sedimentation-flotation tank be installed about 150 feet downstream from the spring, just far enough away so as not to detract from the naturalness of the area around the spring. It can be formed simply by the construction of an earthen dam across the stream and excavation of the area behind the dam down as low as bedrock will permit. The water elevation in the sedimentation tank should be set so as not to flood the spring itself or the first 100 feet or so of the stream. As detailed in the enclosed design notes, the sedimentation tank should be approximately 16 feet wide by 131 feet long, for a total water surface area of approximately 2150 square feet. The average depth should be approximately four feet, so that the total volume is approximately 8400 cubic

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feet. This should provide plenty of time for the iron to completely oxidize and settle to the bottom as iron rust, and for the diesel oil to rise to the surface. The withdrawal device from the tank should be a perforated pipe approximately 30-50 feet long, set approximately one foot below the water surface. The size of the tank is such that it should provide plenty of time for sedimentation and floatation and plenty of buffer against disturbances in the water from weather events in order to prevent excessive loss of either iron floc or oil to the stream below.

We propose that a permanent sludge withdrawal pump be installed in a buried, insulated pit adjacent to the dam, in order to prevent freezing in cold weather, with a flexible discharge hose which can be coiled up into the pit. Iron sludge should be pumped into a slow sand filter box approximately once a month, as necessary. In no case should the sludge level be allowed to rise higher than within three feet of the water surface. In order to determine this, a target can be set in the water slightly over three feet deep, and the pumping instituted as soon as the sludge level rises so as to begin to cover the target. The slow sand filter should be approximately ten feet square, built out of concrete block, with a packing of about three feet of sand. It should include a splash pad against which the hose can discharge, and perforated pipe underdrains, which can discharge back to the stream below the dam. As necessary, probably several times per year, the diesel fuel on the surface should be skimmed to one end and pumped by a commercial septic tank pumper.


We are confident that this arrangement, which is the simplest and cheapest one which we believe will be effective, will solve most of your water quality problems and allow virtually unlimited use of the waters downstream from the treatment tank. Unfortunately, there is nothing we can do to clean up the spring itself, so the visually-degraded spring and the treatment plant will simply have to be used as an educational exhibit demonstrating how misuse of the land can cause virtually permanent damage to a water supply even after the land abuse is stopped, and also how technology can clean up past damage.

We will be glad to meet with your design engineers to explain any of our design calculations and recommendations, and to discuss any other alternative suggestions for cleaning up the water.

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Thank you for the opportunity to be involved in such an interesting project and to be of service to the Cumberland Museum.

Sincerely yours,

A handwritten signature in dark ink, appearing to be 'Ed' or 'E.L.', written in a cursive style.

Edward L. Thackston  
Professor and Chairman

ELT:bl

Enclosures

## REPORT ON WATER TESTING AT GRASSMERE SPRING

Grassmere Spring is a small spring on a two-hundred acre farm in southeast Nashville. The spring appears highly polluted, with a rust-colored sediment and algae covering its bed and a strong smell of diesel fuel. The Cumberland Museum, which has been deeded the land, wishes to have a treatment facility designed that will render the water safe for consumption by livestock and suitable for aquatic life. One parameter of the facility is that it be of as low cost as possible, the Museum being low on cash, but having a good deal of land at this site.

The objectives of the project were as follows:

1. The main objective was the collection of data to determine the extent and types of the pollution of the spring and stream.
2. This collection of data is to be used for the design of a low-cost treatment facility to be built by the Cumberland Museum; this will almost certainly be an oxidation and settling pond of some sort.

The following tests and measurements were carried out:

A. The flowrate of the spring was calculated by measuring the height of water flowing through a notched weir.

B. Chemical tests

1. Measurements of dissolved oxygen were performed on site by the use of a dissolved oxygen meter. The measurement of dissolved oxygen indicates whether additional aeration will be required in the design of the treatment facility.

2. An acidic permanganate titration was carried out to measure short-term oxygen demand. One liter of water was acidified with sulfuric acid and titrated with .100 N potassium permanganate. This titration indicates the amount of ferrous ion contained in the water.

3. pH was measured both in the field and in the lab by use of a pH meter. Certain levels of pH (above 6.5) are necessary for sufficiently rapid oxidation of ferrous ion to take place.

4. Six different analyses were performed using an atomic absorption spectrophotometer, a device that can detect minute traces of metals in liquid solutions, and which gives the concentrations of these metals. These analyses were as follows:

- a. Iron (Fe) was first tested for with unaltered samples of water. This measurement gave the quantity of soluble iron in the water.

- b. The water was then treated with acid to render all the iron soluble, and re-analyzed. This measurement gave the total iron concentration.

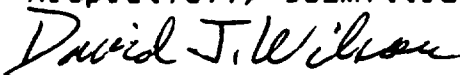
- c. Cadmium, a highly toxic metal, was tested for in the sample.
  - d. Lead, also very toxic, was tested for in the sample.
  - e. Zinc was tested for.
  - f. Copper was tested for; this is not very toxic to animals, but is quite toxic to aquatic plants.
5. The amount of settleable iron in the water was measured by allowing one-liter samples of water to stand for 24 hours in Imhoff cones (calibrated conical flasks) and periodically observing the volume of floc precipitated in the calibrated conical tip of the flask.
6. The amount of heavy (non-volatile) hydrocarbons (oils, greases, etc) in one liter samples of the water was determined by extracting one liter of water with approximately 10 ml of hexane, in which the organics are extremely soluble. This hexane was then drawn off from the neck of a 1-liter volumetric flask, placed in a small weighing boat, and the hexane evaporated off, leaving the non-volatile organics behind. The boat was then reweighed, giving the concentration of oils and greases in the water.

The results of these analyses are presented in the accompanying table.

We draw the following conclusions from the data obtained. First, the concentration of dissolved oxygen is probably sufficient to oxidize the ferrous ion, given sufficient time. Secondly, the major contaminant is hexane-extractable oils and greases. Thirdly, the concentrations of highly toxic metals and organics are sufficiently low that the sludge from any settling operations will not be a hazardous waste material and can be disposed of by landfilling. Fourthly, the flow measurement taken on Dec 16, 1985, after a period of prolonged and heavy rain, provides an indication of spring characteristics under conditions of quite heavy flow. Lastly, the data and observations taken on the small spring do not indicate any sign of contamination. Enough data have now been collected on the large spring to enable Dr. E. L. Thackston, of the Civil and Environmental Engineering Department at Vanderbilt, to design the treatment facility.

#### References

Sawyer, Clair N., and McCarty, Perry L., Chemistry and Environmental Engineering, McGraw-Hill Book Co., St. Louis, 1978.

Respectfully submitted  
  
 David J. Wilson, Ph. D.

## Data for Grassmere Spring

Date	Flowrate (cfs)	pH	DO (ppm)	Hexane extractable (ppm)	Fe(tot) (ppm)	Fe(sol) (ppm)
Sep 26 84	.07-.14	6.5-6.6	3	--	--	--
Nov 11 84	.27	6.8-6.9	3.2	67	3.2	.47
Dec 22 84	.29	6.8-7.0	3.4	56	3.1	.39
Jan 9 85	.33	7.0	4.2	66	3.0	.45
Jan 10 85	.23	7.1	4.0	69	3.5	.75
Jan 14 85	.27	7.2	3.7	109	1.7	1.2
Jan 16 85	.27	7.3	3.6	157	--	--
Average	.29	6.94	3.7	87	2.9	.65
Std. dev.	.027	.27	.35	35	.62	.30
Dec 16 85*	.69	6.9	--	28	3.2	.73

Date	Cd (ppm)	Pb (ppm)	Zn (ppm)	Cu (ppm)	Oxygen Dem. (mg/L)	Remarks
Sep 26 84	--	--	--	--	--	
Nov 11 84	n.d.	n.d.	.04	.11	--	No chlorinated solvents or chlorinated pesticides
Dec 22 84	n.d.	n.d.	.05	.09	.72	
Jan 9 85	n.d.	n.d.	.04	.10	.96	
Jan 10 85	--	--	.02	.10	.48	Settleable floc (2 days) 1.2-1.3 ml/L
Jan 14 85	--	--	--	--	.36	
Jan 16 85	--	--	--	--	.40	Oxygen demand on 2-day-old sample = .56 ppm
Average	0	0	.036	.10	.54	
Std. dev.	0	0	.013	.007	.22	
Dec 16 85*	0	< .2	.2	<.1	--	No chlorinated organics

\*There had been prolonged and heavy rain prior to Dec 16, 1985.

The small spring at Grassmere was sampled on Dec 16, 1985 and analyzed for metals and chlorinated organics. No chlorinated organics were detected. The metals analyses were as follows.

Sample 1	Cu - 0.0	Cd - 0.0	Pb < 0.1	Zn	0.16 mg/L
Sample 2	Cu - 0.06	Cd - 0.0	Pb < 0.1	Zn	0.14 mg/L

DESIGN NOTES 2 2 0324 (1)  
GRASSMERE SPRING SEDIMENTATION TANK

DESIGN FLOW

Max. Measured flowrate (12/16/95) = 0.69 cfs

Assume max flowrate  $\approx 1.0$  cfs for safety's sake

$$1.0 \frac{\text{ft}^3}{\text{sec}} \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \times \frac{60 \text{ sec}}{\text{min}} = 448.8 \text{ gal/min} \approx 450 \text{ gal/min} \\ \approx 646,000 \text{ gal/day}$$

SEDIMENTATION TANK AREA

Assume Very Conservative Loading rates ( $200-500 \frac{\text{gal}}{\text{day} \cdot \text{ft}^2}$ )

$$\frac{646,000 \text{ gal/day}}{200 \text{ gal/day} \cdot \text{ft}^2} = 3230 \text{ ft}^2$$

$$\frac{646,000 \text{ gal/day}}{300 \text{ gal/day} \cdot \text{ft}^2} = 2150 \text{ ft}^2 \quad \checkmark$$

$$\frac{646,000 \text{ gal/day}}{400 \text{ gal/day} \cdot \text{ft}^2} = 1615 \text{ ft}^2$$

$$\frac{646,000 \text{ gal/day}}{500 \text{ gal/day} \cdot \text{ft}^2} = 1290 \text{ ft}^2$$



## TANK SHAPE

Long and narrow is best hydraulically.

Long and narrow would fit best into area available

Long would provide most fall in stream, and therefore most height at "dam" without excessive excavation.

Assume  $L/W \approx 8$

$$8W \times W = \text{Area}$$

$$W = \sqrt{\text{Area}/8}$$

<u>Area</u>	<u>W</u>	<u>L</u>
3230	20	161
2150	16	131
1615	14	114
1290	13	102

✓

# TANK DEPTH AND VOLUME

For 16' x 131' Tank (2096 ft<sup>2</sup>)

D = 3'	Vol = 6288 ft <sup>3</sup>	T = 6288 sec	T = 1.75 hr.
D = 4'	Vol = 8384 ft <sup>3</sup>	T = 8384 sec	T = 2.33 hr.
D = 5'	Vol = 10480 ft <sup>3</sup>	T = 10480 sec	T = 2.9 hr.

For 14' x 114' Tank (1596 ft<sup>2</sup>)

D = 3'	Vol = 4788 ft <sup>3</sup>	T = 4788 sec	T = 1.33 hr.
D = 4'	Vol = 6384 ft <sup>3</sup>	T = 6384 sec	T = 1.77 hr.
D = 5'	Vol = 7980 ft <sup>3</sup>	T = 7980 sec	T = 2.2 hr.

For 20' x 160' Tank (3200 ft<sup>2</sup>)

D = 3'	Vol = 9600 ft <sup>3</sup>	T = 9600 sec	T = 2.67 hr.
D = 4'	Vol = 12800 ft <sup>3</sup>	T = 12800 sec	T = 3.55 hr.
D = 5'	Vol = 16000 ft <sup>3</sup>	T = 16000 sec	T = 4.44 hr.

Adopt 16' x 131' Tank, 4' deep  
Keep sludge depth to max of 1 foot

Therefore, Detention time at Max. flow will be 1.75 hours.

## FLOC VOLUME

Total Iron varied from 1.7 to 3.5 mg/l  
Std. Dev. was 0.62 on a mean of 2.9 mg/l

There was no correlation of Concentration with flow rate.  
Highest conc. ~~was~~ (3.5) was at lowest Q (0.23)  
Next highest conc. (3.2) was at highest Q (0.69)

Six of seven iron measurements were 3.0 or above.

Assume max. floc production at 3.5 mg/l at 1.0 ft/sec.

$$\begin{array}{lcl} \text{M.W. Fe(OH)}_3 & = & 107 \\ \text{M.W. Fe} & = & 56 \\ 107/56 & = & 1.91 \end{array}$$

Therefore, max. floc production =  $1.91 \times 3.5 = 6.68 \text{ mg/l}$

In settling tests, floc concentrated to 19,550 mg/l in 18 in.  
Most concentration occurred in first 30 min - 60 min.

$$6.68 \text{ mg/l} \times 8.34 \approx 56 \text{ lb/Mil gal (dry sludge)}$$

$$\frac{56}{0.019} = 2935 \text{ lb/Mil gal (Wet sludge)}$$

## FLOC VOLUME (Cont.)

If sludge is produced at a rate of 2935 lb of wet sludge per million gal of flow, and max. flow is 0.646 mgd,

$$\text{Max sludge production} \approx 0.646(2935) \approx 1896 \text{ lb/day}$$

At a nominal density of 63 lb/ft<sup>3</sup>,

$$\text{Vol} = \frac{1896 \text{ lb/day}}{63 \text{ lb/ft}^3}$$

$$\text{Vol} \approx 30 \text{ ft}^3/\text{day}$$

Tank will have approximately 2000 ft<sup>3</sup> of sludge storage

or  $\frac{2000 \text{ ft}^3}{30 \text{ ft}^3/\text{day}} = 66 \text{ days} \approx 2 \text{ months sludge storage.}$

Recommend pumping out sludge once each month.

